Downloaded from rspa.royalsocietypublishing.org

PROCEEDINGS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Report of Private Expedition to Philippeville, Algeria, to View the Total Eclipse of the Sun, August 30, 1905

T. C. Porter and W. P. Colfox

Proc. R. Soc. Lond. A 1907 **79**, 296-310
doi: 10.1098/rspa.1907.0042

Email alerting service

Receive free email alerts when new articles cite this article - sign up in the box at the top right-hand corner of the article or click **here**

To subscribe to *Proc. R. Soc. Lond. A* go to: **http://rspa.royalsocietypublishing.org/subscriptions**

This journal is © 1907 The Royal Society

Downloaded from rspa.royalsocietypublishing.org

Report of Private Expedition to Philippeville, Algeria, to view the Total Eclipse of the Sun, August 30, 1905.

By T. C. Porter, M.A., D.Sc., F.R.A.S., etc., and W. P. Colfox.

(Received November 27, 1906,—Read May 30, 1907.)

[Plates 4 and 5.]

General Objects:—

To examine—

(*a*) The height of the reflecting layers of the atmosphere.
(*b*) The structure of the corona.
(*c*) The polarisation of the corona.
(*d*) The coronium ring.
(*e*) The shadow bands.
(*f*) The meteorological conditions of the eclipse.

Our station was near Philippeville, about 1·5 kilometres to the west-north-west of the village of Saint Charles, on the long and broad summit of a grassy hill rising at a moderately steep slope. The position of our camp, as given by the large-scale survey map, was:—

N. Lat., 36° 45′ 38″·7.
E. Long., 6° 51′ 59″·1, or in time, 0 h. 27 m. 27·6 s.
Height above sea-level, 690 feet or 210 metres.

These values agreed well with independent observations made with sextant and telescope.

A space on the north side of the hill, and about 5 feet below the highest plane, immediately under and to the north of a thick bushy tree, about 16 feet high, was cleared of grass and levelled by Arabs. On this we set up a double-roofed tent, and were thus greatly protected from the sun during the heat of the day.

The circumstances of the eclipse for our position, which was almost exactly on the line of central eclipse, are given in the following table; the time, unless otherwise stated, being our *Camp mean time.*

The second contact was observed with a field glass, one objective of which had a direct-vision prism before it. The third was observed with the same apparatus as the second, but a "coronium green" screen was placed before the otherwise bare objective, a plan which the observer thinks is to be strongly recommended. The fourth contact was observed through the 4-inch telescope, with a power of 120, and suitable screen.

The Royal Society is collaborating with JSTOR to digitize, preserve, and extend access to *Proceedings of the Royal Society of London. Series A, Containing Papers of a Mathematical and Physical Character.* www.jstor.org

Downloaded from rspa.royalsocietypublishing.org

Contact.	Calculated from N. A.	Observed.	Possible error, if + to be added to the mean time.	Position angle.	Angle between N. Pt. and vertex.
	h. m. s.	h. m. s.	s.	° ′	° ′
1st	0 40 9·9	—	—	295 43	16 21
2nd	2 0 10·0	1 59 58	−6	115 21	39 48
3rd	2 3 47·2	2 3 34	+1	293 39	
4th	3 16 59·6	3 16 46	−1	114 54	50 0

As the position of our camp was isolated, we depended upon our own observations for the time, and also for the determination of the watch's rate error. The watch was a half-chronometer by "Longines" 1201182; it lost 1·8 secs. per hour, and the resulting errors in times of observation have been allowed for in the above table. To find the time, we used the method of equal altitudes, making the observations with the sextant and artificial horizon.

The seconds during totality were given by a metronome, and the duration of totality by using a stop-watch from second to third contact.

The apparent diameter of the sun at the observing station was

$$0^\circ\ 31'\ 44''{\cdot}73.$$

The apparent diameter of the moon at the observing station was

$$0^\circ\ 33'\ 15''{\cdot}18.$$

Apparatus.—This was of so simple a nature that it may be very shortly described:—

(1) A 4-inch clear altazimuth telescope of 5 feet 4 inches focal length, by Dollond, of excellent performance. It had no driving clock, slow motion in R.A. and Decl. being given by two handles worked by the observer. Originally it was intended to use this telescope for photographic purposes, and a special circular plate carrier was designed and made for the purpose, but it was found that the vibration was too great, even with rapid exposures, and so the instrument was used visually.

(2) A brass-bound stereoscopic camera, with Zeiss anastigmat lenses of 6·5-inch focus, each lens having in front of it a large Nicol prism. The camera and Nicols were mounted together on one stand, all being adjustable in altitude. This was placed in position the day before the eclipse, and focussed with a special high-power lens by Dallmeyer. For the stand, and for that mentioned in (3), our thanks are due to Mr. R. W. Kennedy.

(3) A 14-inch by 10-inch camera, with a Dallmeyer's R.R. lens of 16·5-inch

Downloaded from rspa.royalsocietypublishing.org

focal length, used at aperture f/8·5, and covered with a special green screen, described later, supplied by Messrs. Sanger Sheppard and Co., for the purpose of transmitting green coronium light and little else.

(4) A quarter-plate and half-plate camera, each with its stand, also standard thermometers, a fine aneroid barometer by Browning, sextant, artificial horizon, and other accessories.

(5) A portable dark tent, with table, which was used solely for placing the plates in the holders the night before the eclipse. The plates used were specially made by Messrs. Cadett; they were sensitised for the whole spectrum, very well backed, packed in tins, the cover of each tin being held in position by a strip of surgeon's plaster. Although these plates went through all sorts of temperatures from 12° up to 40° C., they showed no trace of deterioration, though they were not developed for more than two months after exposure. Development took place in total darkness for the most part.

General Observations during the Eclipse.—From a few minutes after first contact, the progress of the eclipse was watched through the 4-inch; and the times (St. Charles mean time) of the disappearance, and, after totality, the times of reappearance, of the four groups of sun-spots visible were carefully noted as follows:—

	h. m. s.	h. m. s.	h. m. s.	h. m. s.
Disappearance	1 17 4	1 43 44	1 52 34	1 56 36
Reappearance	2 37 44	3 1 4	3 5 14	3 12 54
Small train of spots uncovered at	3 2 44			

From the rate of the moon's motion and the path of its centre across the sun, the apparent positions of the spots (within 23 secs.) on the sun's disc have been calculated, and are indicated in fig. 1, which also gives the circumstances of the eclipse as seen from our camping place.

Some interest attaches to these spots, especially to (*c*) and (*d*), notably (*d*), which lay close to the limb. The great north-east prominence—such a noticeable feature of this eclipse—was situated, as the figure shows, just above the region of these spots.

At 1 h. 42 m. an observation of the amount of atmospheric "flare" round the sun showed that it was considerable; it could be traced fully 8° from the sun's limb; the observer, who has made a special study of this flare in many latitudes and at various altitudes, considered, from the character of the flare, that in all probability the particles causing it were not at any very great altitude, nor in a layer of great thickness. The distant hills, quite 30 miles off, were beautifully clear, so that the stratum of dust seemed certainly above us.

Downloaded from rspa.royalsocietypublishing.org

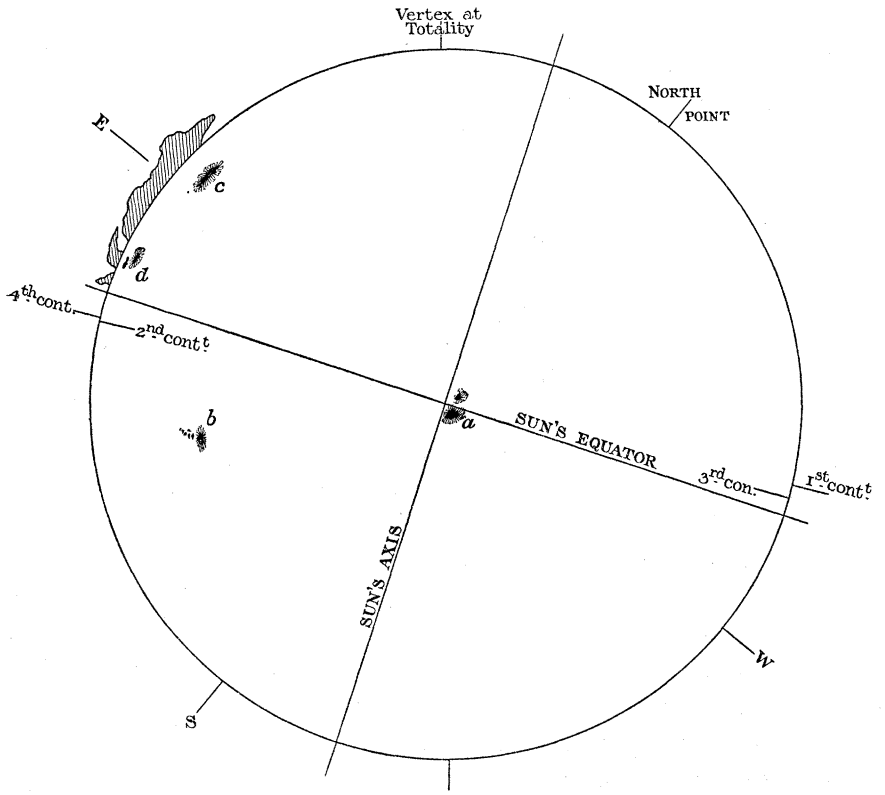


FIG. 1.

Taking 5° as the upper limit of the brilliant orange glow seen above the south-west horizon, at from 6 to 9 secs. after central totality, we find, for the *upper* limit of the stratum of reflecting matter in the atmosphere, almost exactly 6 miles, a result coming near the inferior limit given by a very large number (many hundreds) of observations made by the present writer during many years in different latitudes at sunrise and sunset. If h be the required height, A the altitude of the orange glow, P the position of the observer, O the centre of the earth, Q the observed greatest altitude of the glow, and B the angle POQ, then from fig. 2 given below it is easily seen that $(h + r)/r = \cos A/\cos(A + B)$, which at once gives h.

Photographs and Visual Observations of the Corona.

(a) Unassisted visual observations: A drawing, on a previously prepared scale, was made by W. P. C., who possesses very keen sight, of the three most prominent coronal streamers. The observer had carefully abstained from looking at the solar crescent for some little time before totality, but had not

Downloaded from rspa.royalsocietypublishing.org

closed his eyes, as he was busily engaged in observing the shadow-bands. Of the two streamers near the south pole of the sun, the more remote he could trace with certainty for 2·0 moon's diameters, *i.e.*, 1° 6′ 30″; whilst that nearer to the pole certainly extended one-tenth of the diameter further, *i.e.*, 1° 9′ 30″. The third streamer, which lay in the north-west quadrant, extended visibly not quite 1·5 lunar diameters from the limb, or 0° 50′. No screen was used to hide the inner corona from the eye.

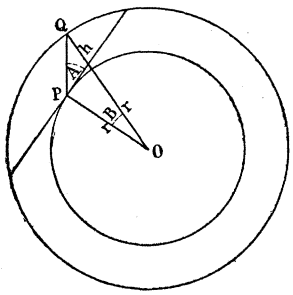


Fig. 2.

(*b*) Two photographs of the corona were taken simultaneously through two Nicols inclined at 45° and 135° respectively to the horizontal, and exposed from the 40th to the 45th second after second contact. (See Plate 4, figs. 3 (*a*) and 3 (*b*).)

The effective apertures of the two Nicols were 2 inches and 2·5 inches respectively, and to make the two photographs strictly comparable the aperture of the lens behind the larger Nicol was stopped down till the two images on the ground glass of moderately bright objects seemed, after careful estimation, to be of the same degree of brightness. (This adjustment was very carefully made on August 29.) The plane of polarisation of the atmosphere was roughly ascertained, before the exposure was made, by a rapid survey of the sky with a small Nicol; it was nearly, if not quite, horizontal, so that the atmospheric polarisation affects both the photographs sensibly equally. A glance at the result, figs. 3 (*a*) and 3 (*b*), is sufficient to reveal the fact that the light of the outer corona is powerfully and radially polarised. The longer of the two southern streamers on the left-hand negative can be traced with certainty for 2·2 diameters (0·2 diameter further than the visual estimate) away from the moon, and with equal certainty to within 2′ 7″ of the moon's limb, yet no part of this streamer can be traced with certainty on the negative from which the right-hand print has been made; its light seems, therefore, to be polarised throughout the greater part of its length, and the same thing is true, so far as one can judge from the photographs, of the other streamers. So far as these prints and the negatives from which they are made are concerned, there seems to be unmistakable evidence that either the general brightness, or the extent, or the amount of unpolarised light, or all three, were greater on the north-east side of the sun than on any other side; that is on the side where the great prominence was visible. This can be seen on *both* the simultaneous photographs.

The curved lines of the plume of coronal streamers to the north and south of the great prominence have their convex sides towards the prominence, so

Downloaded from rspa.royalsocietypublishing.org

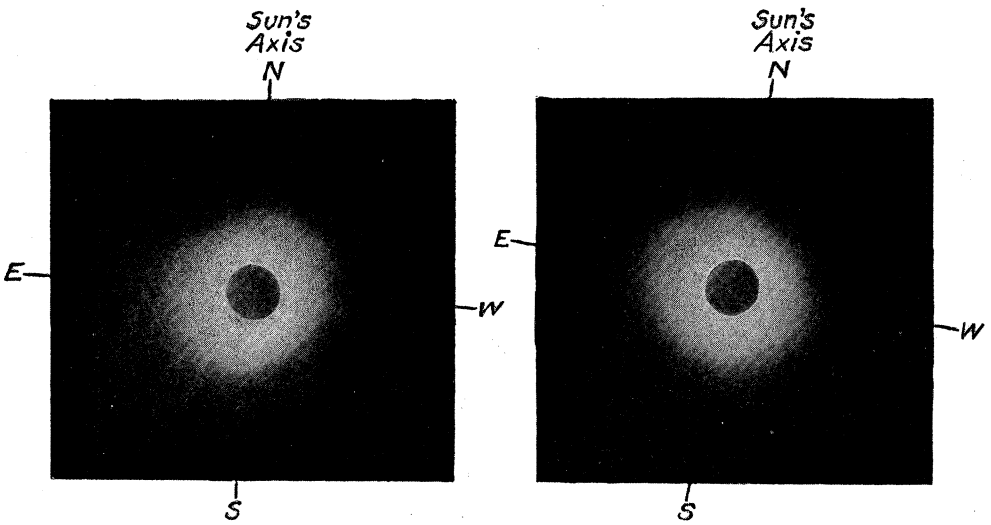


FIG. 3 (*a*).

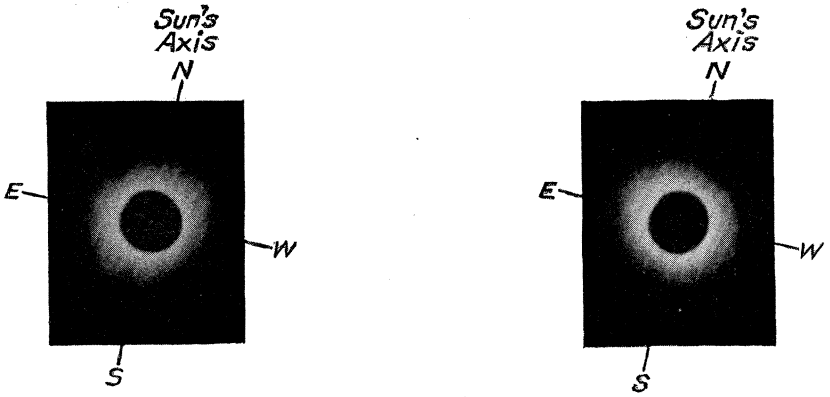


FIG. 3 (*b*).

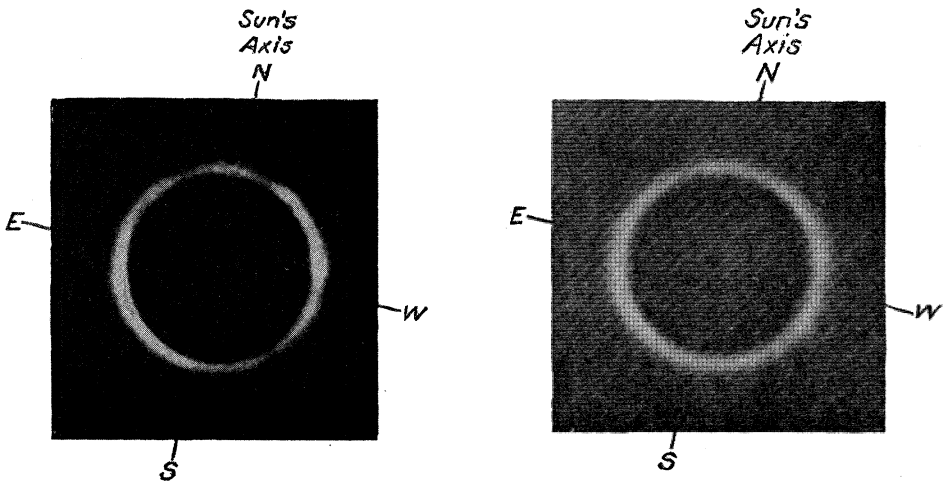


FIG. 4.

PROCEEDINGS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

PROCEEDINGS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Downloaded from rspa.royalsocietypublishing.org

far as we can see, and suggest that even if their cause is independent of the cause of the prominence, yet that the latter has some disturbing influence upon their direction.

Our thanks are specially due to Messrs. Harvey and Peak, of Charing Cross Road, for their great kindness in lending us freely the larger of the two Nicols, without which this part of our work must have been impossible.

(*c*) Visual observations of the *inner* part of the corona with the 4-inch refractor, using the reflecting solar eye-piece, and a light, neutral tinted shade, on the eastern and western equatorial regions of the sun, with a power of 120 diameters, during the last 90 secs. of totality.

(1) *On the Eastern Region, about the Point of Second Contact, along an Arc of about* 35°.—At first the field of view seemed filled with very pale cream tinted light. After three seconds of gazing the detail began to appear, first the broader streamers, and then the finer markings. This gradual appearance was, no doubt, due to purely physiological causes. This part of the corona was exceedingly intricate in structure. From the dark limb of the moon, which in its advance had already completely covered the big prominence, thin, straight, radial streams of pearly white luminous matter stood crowded together, like thin pillars of stalactite in some limestone cavern, or the trunks of young pines in a thick wood. Not far from the limb, these seemed to unite by each one widening at the top, forming what resembled a thin shell of white haze, but the observer failed to note how far this shell extended along the limb. It may have been confined to some 9° to 12°. As to the angular height of the thin pillars, memory would place it at 0° 1′ 40″, and the thickness of the "ceiling" at 10″, but neither dimension was recorded at the time. It is certain, however, that part of this structure lay above part, if not all, of the big prominence (which was, as has been said, invisible). It is also certain that it was crossed obliquely by a few streamers, which were three or four times wider than the pillars, and cut their direction obliquely. One streamer was particularly easy to see. It was curved, with its concave side towards the sun, and made, at the moon's limb, an angle of *apparently* 60° with the radial direction, sloping away from the limb towards the solar south. This columnar structure could scarcely be an upheaved part of the photosphere,* for it lay above the upper limit of the great prominence, and its light was of a different order to the photospheric. It may have been due to eruptive matter, reduced to a linear form by threading the spaces between the condensed matter which forms the faculæ. If, then, some of the constituents of these columns condense, these may form the luminous "ceiling" described, which will act as a reversing layer to the light of these

* *Vide* Mr. J. Evershed, 'Report, Eclipse Exped. Pineda de la Sierra, Spain,' p. 55.

Downloaded from rspa.royalsocietypublishing.org

components of the columns, whilst the uncondensed material passes on. When, during later condensation, its particles attain the right size, they will be driven away from the sun by light-pressure, forming the corona.

(2) *Telescopic Observations on the Western Equatorial Region.*—Nothing of the kind seen in (1) was visible, but it is just possible it may have been overlooked. The faint, softly defined, yet distinct outlines of the streamers seemed to cross one another at all sorts of angles; but before any rough quantitative measurements could be made, a number of luminous jets were gradually uncovered by the dark limb, giving to the latter a serrated appearance. These jets were exceedingly beautiful. They had very narrow, sharply defined, brilliant white, or greenish white stems (next the sun) and these stems rapidly widened into pear, or crocus-bud shaped heads, their colour passing by insensible gradations from the glowing white of the stems into rounded soft looking summits of the bluish-pink of the cyanogen flame. They nowhere resembled the crimson of the hydrogen "vacuum" tube. Some 10 of these were visible in an arc of the moon's limb subtending about 40° at the centre. They seemed perfectly stationary. The dark limb of the moon was quite steady and sharply defined, in fact the "seeing" throughout totality was unusually good. There is no doubt in the observer's mind that some of the inner coronal streamers could be traced down to the upper limit of these brilliant jets, which he supposes were part of the chromosphere.

(*d*) On the photograph of the "coronium ring": This was taken at central totality, with the lens and camera described under Apparatus, heading (3), with 5 secs. exposure, f/8·5, with the green screen. The result is shown in the two prints from the intensified enlargement (fig. 4). The lighter of the two prints shows the utmost extent of the radiation, which corresponds to some 123,000 miles above the photosphere in the places where it is highest, and 61,000 miles where it is lowest. The darker of the two prints is from the same negative, and is intended to show the detail present in the ring. Not less than 40 glowing points or jets can be counted on the negative, and their distribution does not show any obvious relation either to the ordinary prominences nor yet to the coronal streamers. They seem to be a phenomenon *per se*. To find what radiations the screen used would have allowed to pass had they been present, four photographs of the ordinary solar spectrum were taken with direct sunshine through the screen, on the same kind of plate as was used in the eclipse and, moreover, one of the same dozen. The shortest exposure, 5 secs., shows a faint band with limits of wave-length at 5181 and 5577, and with maximum at 5508.

It might well be suggested that these jets were not of coronium, but of some matter giving a continuous spectrum; if so, they might be expected to

Downloaded from rspa.royalsocietypublishing.org

show on other photographs, not taken through a green screen, and they do not; but this may be answered by saying that their light is swamped when *all* the light of the inner corona is allowed to fall on the photographic plate. If we set aside this explanation and search among elements known to exist in the upper chromosphere or in the corona, by strong lines within the range of the spectrum transmitted by the screen, 5181—5577, then the choice seems to be limited to—

(1) Magnesium, "*b*" lines: impossible with the exposure given, and evidence from Guelma that the Mg lines faded out before central totality.

(2) Coronium, 5303.

(3) Helium or hydrogen: practically out of court, from the nature of the light transmitted by the screen, and also much evidence to prove that the coronal material is independent of the H and He of prominences.

(4) Iron enhanced lines, 5169, 5316, 5363, and 5535: all most unlikely, from their faintness and from the elevation of the "coronium ring."

(5) Unknown element, 5425: if the detail is due to this, it should have been noticed in the corresponding ring of the slitless spectrographs made at Guelma, and this is apparently not the case.

Thus the bright points are almost certainly due to coronium.

Observations of the Shadow Bands.—These were particularly well seen, both before and after totality. In order to observe them, a white sheet, about 12 feet by 9 feet, was carefully orientated and stretched on level ground. Several staves of white wood, 2 metres long and 2 cm. wide, some marked and some plain, were used to determine the direction of the length of the shadow bands, both before and after totality. About 4 minutes before totality one could see that "something" was passing over the sheet. Gradually the bands grew more distinct, and were plainest about 2 minutes before second contact. The observer could not feel certain whether they disappeared before totality, they certainly grew more indistinct. Before totality, the breadth of the dark part of each band was about 0·5 inch, after totality they were certainly thicker—about 1 inch—and not only more distinct, but more distinctly waved. The distance between the bands was the same, both before and after totality, namely 4 inches, with a possible error of ± 1 inch. After totality, they remained visible for 3 m. 30 s., the time of their disappearance being well observed. When most distinct, the bands were dark grey in the middle of their breadth, but shaded off gradually but quickly at the edges. They were not coloured. The rate at which they travelled, measured at right angles

Downloaded from rspa.royalsocietypublishing.org

to their length, was estimated at from 6 to 7 miles an hour. They were scarcely, if at all, visible on surrounding objects, and it seems clear that to observe them successfully, a smooth, white surface must be used. An attempt to photograph them before totality failed. A second sheet was stretched over some low bushes in front of a camera, but, unfortunately, it was not sufficiently secured and became creased, when too late to remedy the fault.

The direction of the bands themselves before totality was from 38° east of north to 38° west of south, and was the same within the errors of experiment after totality. As a matter of fact, the after-totality stick made an angle of 0° 22′ with the before-totality stick, lying nearer the north and south line by these 22′.

These directions coincide, within half a degree, with the trace on the horizontal sheet (on which the bands were observed) *of the plane passing through the cusps of the solar crescent and the sheet.* Being almost exactly on the line of central totality, the angle through which the trace of the cusp line rotated during totality was very small, but, so far as the observation went, the bands rotated with it. This is the first time, the writers believe, that such evidence has been adduced. It accounts completely for the rotation of the direction of the bands' length noticed in many instances where the observers were *off* the central line, and explains why sometimes the bands are not seen; for if the lines of differently refractive material in the air are not nearly parallel to the cusp line, it is obvious that no shadows will be cast. This last statement has since been proved by direct experiment with an artificial eclipse. The true direction in which the bands travel has *never* yet been determined; they *appear* to move at right angles to their length, but this must *always* be the case with endless lines which have no distinguishing marks upon them. In the present instance the ripples on the bands, viewed "end on," seemed to have an independent motion along the bands from south-west to north-east, and this makes it certain that the *true* direction of travel of the bands was *not* at right angles to their length: nevertheless, if the eye fixed on any particular wave, it seemed, viewed from most positions, whilst it lasted, to move "straight forwards." The velocity of the ripples along the bands would, therefore, appear to be small when compared with the velocity of the bands themselves.

Meteorological Data of the Eclipse.

General Statement.—(*a*) Barometric observations, made with an open-scale aneroid by Browning, which has been used for many years, and is thoroughly known by one of the observers. The instrument has been proved to be well compensated for temperature; its errors have been determined from time to

Downloaded from rspa.royalsocietypublishing.org

time by comparison, over a *narrow* range only, with a standard Fortin, under *naturally* (and therefore slowly) varying conditions of temperature and pressure and found to be at least as reliable as the best instruments of its class. It could be read correctly to 0·02 of an inch (0·7 mm.).

In making the meteorological chart, Plate 5, the readings have all been reduced to 0° C. and sea-level for the sake of comparison.

NOTE.—Owing to a mistake in the first estimate of the height above sea-level of the observing station, all the barometrical readings on the curve are 1·7 mm. too low.

(*b*) Thermometric observations: (1) The air temperature, read from a standard mercury thermometer (°F.), in the shade, about 4 feet from the ground. The readings are reliable to 0°·1 C.

(2) A standard "black bulb *in vacuo*" solar radiation thermometer, *un*shielded, and therefore showing, in addition to the solar, the radiation from the sky, and surrounding objects. This was fastened to the telescope stand in a fixed position, so that the sunshine fell on the bulb uninterruptedly from sunrise to sunset. The readings are accurate to 0°·1 C.

In the curves on Plate 5, no allowance has been made for this lag of the instrument in giving its indication, but on the *separate* radiation time curve, fig. 5, such an allowance has been made, based on the results of a direct comparison of the instrument's indications with those of a thermo-

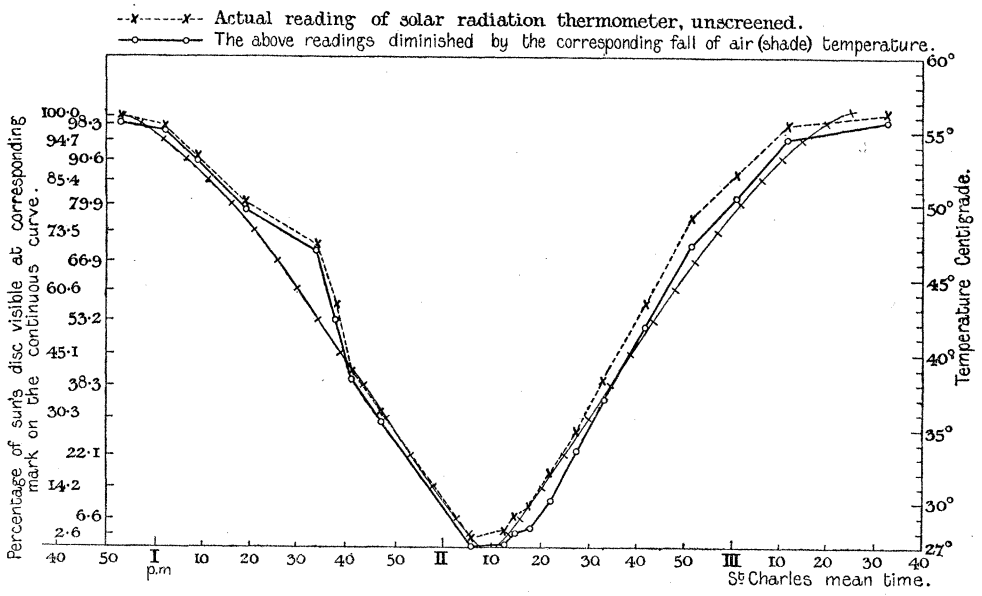


FIG 5.

Downloaded from rspa.royalsocietypublishing.org

pile, during an artificial "heat" eclipse, made roughly to imitate the real. The indications during the first and last part of the covering and uncovering of the sun's disc seem to have been approximately 8 minutes late.

(*c*) Measurement of the relative humidity of the air. The dry and wet bulb method was followed with the usual precautions. The apparatus was placed about 4 feet above the ground, the thermometers shielded from all but "light airs," and kept always in the shade. In every case the relative humidity has been derived from the readings by means of the formula—

$$\text{Relative humidity} = \frac{T_{w.b.} - a\,(T_{d.b.} - T_{w.b.})}{T_{d.b.}} \times 100,$$

where

$T_{w.b.}$ = Tension of aqueous vapour at wet bulb temperature,

and

$T_{d.b.}$ = „ „ dry „

whilst "a" is a factor depending on the barometric height, and having a value between 0·6056 and 0·6035 in these reductions.

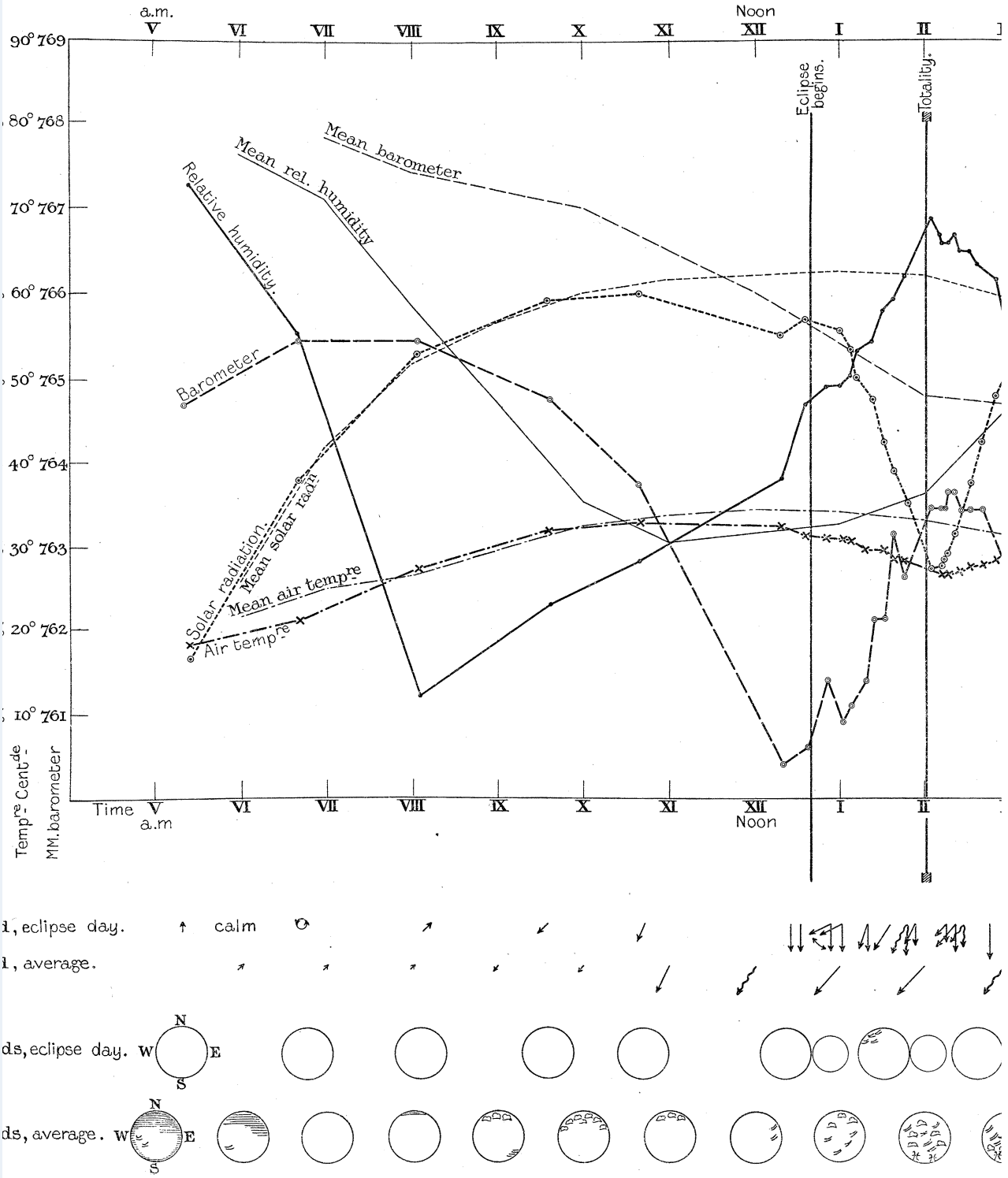
It will be seen on the chart that two curves are given for each of the quantities observed, *i.e.*, the mean curve, and that for August 30, the day of the eclipse. Since the observations were limited to four days in all, it would be wrong to attach any great importance to the mean observations, were it not that one day very closely resembled another, and also that, as far as we could learn, the weather was of the usual kind for the end of August.

(*d*) Observations of wind were regularly kept. On the chart, the wind's direction, force, and character are given for every hour of the day from 5 A.M. till 6 P.M. As usual, the lengths of the arrows denote the force, each division of the chart-scale corresponding to ten units on the ordinary scale of wind-force: thus the strongest winds shown mean strong breezes of force 4. The arrow points *with* the wind, *i.e.*, to the quarter towards which the wind was blowing at the time indicated. If the arrow's stem is straight, it implies a steady wind; if wavy, a gusty wind. Where two or more arrows are drawn diverging from the same point, it signifies that at the corresponding time the wind was uncertain, blowing from either direction alternately, and changing through the acute angle between the arrows. A small circle with an arrow head on it means that the wind was shifting all round the compass in the direction towards which the arrow-head points.

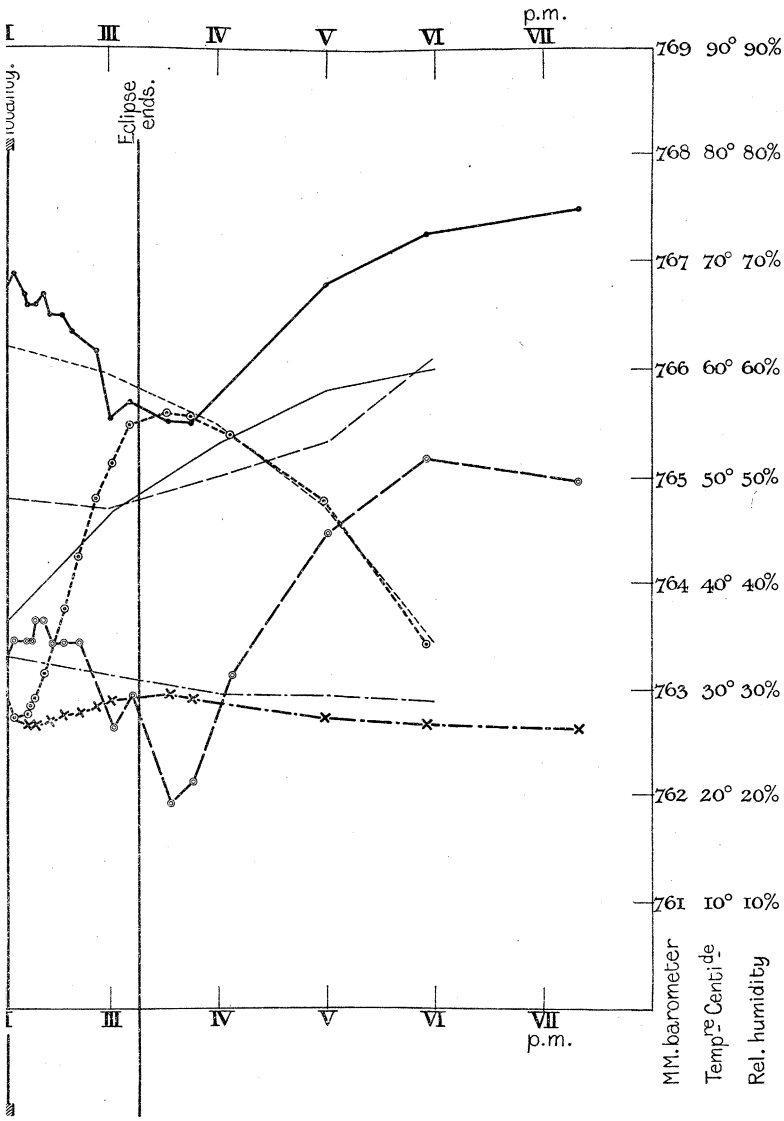
(*e*) Observations of cloud. These are also given for every hour of the day by small circles representing the whole visible sky, in plan, orientated as marked, and the *kind* of clouds, as well as their positions, are indicated by the method explained on the chart itself.

No attempt has been made to *smooth* any of the curves, but their

Downloaded from rspa.royalsocietypublishing.org



Downloaded from rspa.royalsocietypublishing.org



PROCEEDINGS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Downloaded from rspa.royalsocietypublishing.org

jaggedness is not to be attributed to errors of observation, *e.g.*, the minor peaks on the sides of the eclipse barometric "hillock" undoubtedly correspond to real subsidiary barometric fluctuations; that this is so is almost evident from the chart itself, for corresponding fluctuations are clearly traceable, both in the direction and force of the wind and in the humidity curve. The correspondence between the barometric and the humidity curves is remarkable; almost every small peak on the former has a simultaneous variation—a rise and fall—or, more correctly, an increase and decrease in the rate of rise, or a decrease and increase in the rate of fall—on the humidity curve.

The question may be asked—How much, if any, of the "depression" in which the eclipse hillock lies is due to the eclipse? The eclipse began on the earth at 10.30 A.M., G.M.T., in Labrador, ended for the earth generally, off East Africa, at 3.37 P.M., G.M.T., *i.e.*, at 4.7 P.M., St. Charles time. It seems therefore, that the big depression is *not* due to the eclipse, at all events mainly, and we must therefore consider that the first certain effect of the eclipse on the barometer is the pronounced upward turn at 0.30 noon, and that the eclipse ceased to have any *certain* effect at 3.36 P.M.

At 0 h. 30 m., the edge of the *penumbra* was approximately 283 miles away, at a point 60 miles south of Palma. At 3 h. 34 m., the edge of the *penumbra* was 481 miles away, approximately, *i.e.* about 40 miles due east of Tripoli.

The total length of the certainly disturbed barometer district, at any one moment, was, therefore, some 5000 odd miles, the part of it preceding the centre of the *umbra* being some 200 miles shorter than that following it, the isobars being closer together on the advancing front of the disturbance than in its rear. The most rapid barometric rise took place between 1.0 P.M. and 1.45 P.M., whilst the central portion of the sun's disc was being covered. The barometric maximum seems to have travelled some 500 miles behind the centre of the *umbra*, and seems to have covered a region about the same number of miles in length, measured along the line of central totality.

On the Eclipse Wind.—The general effect of the eclipse on the wind was two-fold: First to diminish its intensity, the minimum velocity of the wind occurring (unlike the barometric maximum) during totality, when it sank almost, if not quite, to zero,—and secondly, to make its direction before totality more easterly, and after totality more westerly, than in all probability it would otherwise have been, the influence after totality being the more plainly shown. Both are almost certainly due to the inrush of air from all sides towards the centre of the shadow, where the cooling and consequent contraction of the air were a maximum. Our station was on the central line, and the path of the moon's shadow was roughly from W.N.W. to E.S.E., and

Downloaded from rspa.royalsocietypublishing.org

if it be assumed that the influx of air took place fairly symmetrically, the wind *due to the eclipse* before totality must have been on the whole east-south-easterly, and after totality west-north-westerly, because the *components* of the wind's directions blowing in from opposite sides of the shadow track, *at right angles to that track*, must have neutralised each other, leaving only their east-south-easterly components active before totality, and their west-north-westerly components active after totality.

The actual wind observed was due to the superposition of this eclipse wind proper on the northerly sea breeze, which, though diminished considerably during the middle period of the eclipse, was throughout sufficiently strong to cause the wind to preserve on the whole a more or less northerly direction. It will be remembered that the direction of motion of the shadow bands, though not measured satisfactorily, had, in all probability, a large northerly component, and it is certain that their movement was *towards* the line of central eclipse. The region of higher pressure in the eclipse seems to be an exception to ordinary high-pressure areas in that the air flows *towards* the former, whilst it flows away *from* the latter.

On the Relation between the Solar Radiation, as measured by the unscreened Black-bulb-in-vacuo *Thermometer and the uneclipsed Area of the Sun's Disc.*—This is shown by the three curves in fig. 5 (p. 305):—

(*a*) The continuous black-lined curve shows the fraction of the sun's disc uncovered at any given time during the eclipse, but to get the true time corresponding to a given area from the diagram, it is necessary to subtract 8 m. from the time indicated, *e.g.*, at 1 h. 26 m. on the diagram, 66·9 per cent. of the sun's disc was visible, that is at true mean time, St. Charles, 1 h. 18 m. In this curve the variation of the rate of the moon's motion during the eclipse has been allowed for.

(*b*) The broken line curve of the black-bulb thermometer at the corresponding time indicated in the diagram.

(*c*) The curve with small circles on it, which lies everywhere below the broken line, gives the same temperature as the latter, diminished by the fall of the air shade temperature at the particular time considered.

The times as read in the diagram for (*b*) and (*c*) are approximately 8 m. too late: this is due to the lag of the thermometer.

To illustrate the use of the curve:—Take the indicated time 1.30, or in reality, allowing for the lag of the instrument, 1 h. 22 m. If the temperature had fallen in proportion to the area of the sun's disc covered, the temperature indicated by the thermometer would have been 44°·5 C.; instead of this the temperature shown by the radiation thermometer was 48°·3 C. (or 47°·7 if the fall in the air shade temperature be subtracted from it).

Downloaded from rspa.royalsocietypublishing.org

At the true time, 2 h. 40 m., when the same fraction of the sun's disc was uncovered during the latter part of the eclipse, the temperature, if proportional to the fraction of the solar disc showing, would have been again 44°·5 C. The temperature actually shown by the radiation thermometer was 47° C., and this, minus the fall of the air temperature, is given by the appropriate curve as 45°·4 C.

The general form of the radiation curve fits well with that of the areas uncovered, and the effect of the different radiative power of the margin and centre of the sun's disc is traceable. The bulge on the descending part of the curve is due in all probability to a terrestrial cause, as there is no corresponding bulge on the ascending branch—perhaps the temporary removal of some invisible screen of water vapour between 1 h. 12 m. and 1 h. 26 m.; if reference be made to the cloud chart, Plate 5, it will be seen, curiously enough, that it was during this very time that the only clouds from dawn till 5 P.M., on August 30, *appeared*. The record says: "1.19, some cirrus forming between N.N.W. and W.S.W. . . . ; 1.24 the same, no bigger . . . ; 1.34, clouds in N.W. going . . . ; 1.41, clouds gone." Probably this is but a coincidence, but it is sufficient to show that there were layers of moist air at cirrus heights at the time, and the drifting past the sun of a gap in one of these would amply explain the bulge on the curve.

Stars Visible during Totality.—Several Arabs who stood on the hill during the eclipse kindly consented to keep watch for stars and planets; after the eclipse they pointed out the positions of six stars seen, without optical aid. They were identified as Venus, Mercury, Regulus, Spica, Arcturus, Procyon.

Before closing this paper we wish to give our most hearty thanks to all who helped in any way to make our expedition a success. First, and most of all, to Herbert A. Scratchley, Esq., M.V.O., His Majesty's Consul for Philippeville, without whose great experience and ready advice we should probably never have been able to get into our comfortable quarters in time for the eclipse. He spared no personal trouble for some days to help us in the choice of a site for our camp, and to him we are not only indebted for unvarying kindness and courtesy, but for introductions which proved exceedingly valuable, notably to Monsieur Emile Œttly, Mayor of St. Charles, who procured for us the loan of the school room as a temporary resting place for our apparatus; he it was who engaged Belouahem Mohamed, Arab Garde Champêtre, the man personally responsible for our safety, welfare, and the security of our luggage. M. Œttly also most kindly acted the part of Paymaster, and helped us in a hundred other ways.

We also owe a debt of gratitude to the Deputy-Mayor, M. Jean Roggy

Downloaded from rspa.royalsocietypublishing.org

to M. Pierre Chazerans, Secretary to the Mayor; to M. Jean Gaulin, Garde Champêtre; to Madame V^ve. Sogorb, whose excellent *cuisine* contributed no little to our health and happiness; to our two Arab Guards; and, lastly, to the courtesy of the French Government, which allowed our instruments and personal effects free entry into Algeria.

Chemical Reaction between Salts in the Solid State.

By Edgar Philip Perman.

(Communicated by Principal E. H. Griffiths, F.R.S. Received May 1,—Read May 23, 1907.)

It has long been known that in a mixture of solid salts chemical reaction may take place. Experiments on the subject have been made by Spring (*vide infra*), Thorpe,* and others. My attention was first called to the question by observing that a mixture of arsenious oxide and cadmium nitrate underwent a slow but complete change of composition, the final result being that the nitric acid was eliminated, arsenic acid taking its place.

Preliminary Experiments.—Some experiments were made in order to discover what salts would be suitable for a careful investigation. The following were selected for trial, since a chemical change could be traced by an accompanying change of colour. The salts were finely powdered, but not specially dried.

Salts.	Result on mixing.
Lead nitrate and potassium iodide	Immediate action.
Lead chloride ,, ...	,, ,,
Lead formate ,, ...	Slow action.
Lead sulphate ,, ...	Very slow action, colour appearing after 30 minutes.
Lead oxide (litharge) ,, ...	No appreciable action.
Lead carbonate ,, ...	No change.
Mercuric chloride ,, ...	Immediate action.
Mercuric cyanide ,, ...	No action.
Mercuric chloride and potassium chromate.....	Slow change.

From these salts two pairs were chosen for further study, viz., lead chloride and potassium iodide, and mercuric chloride and potassium iodide.

The salts were purified by recrystallisation, dried over sulphuric acid,

* B. A. Report, 1881, p. 580.

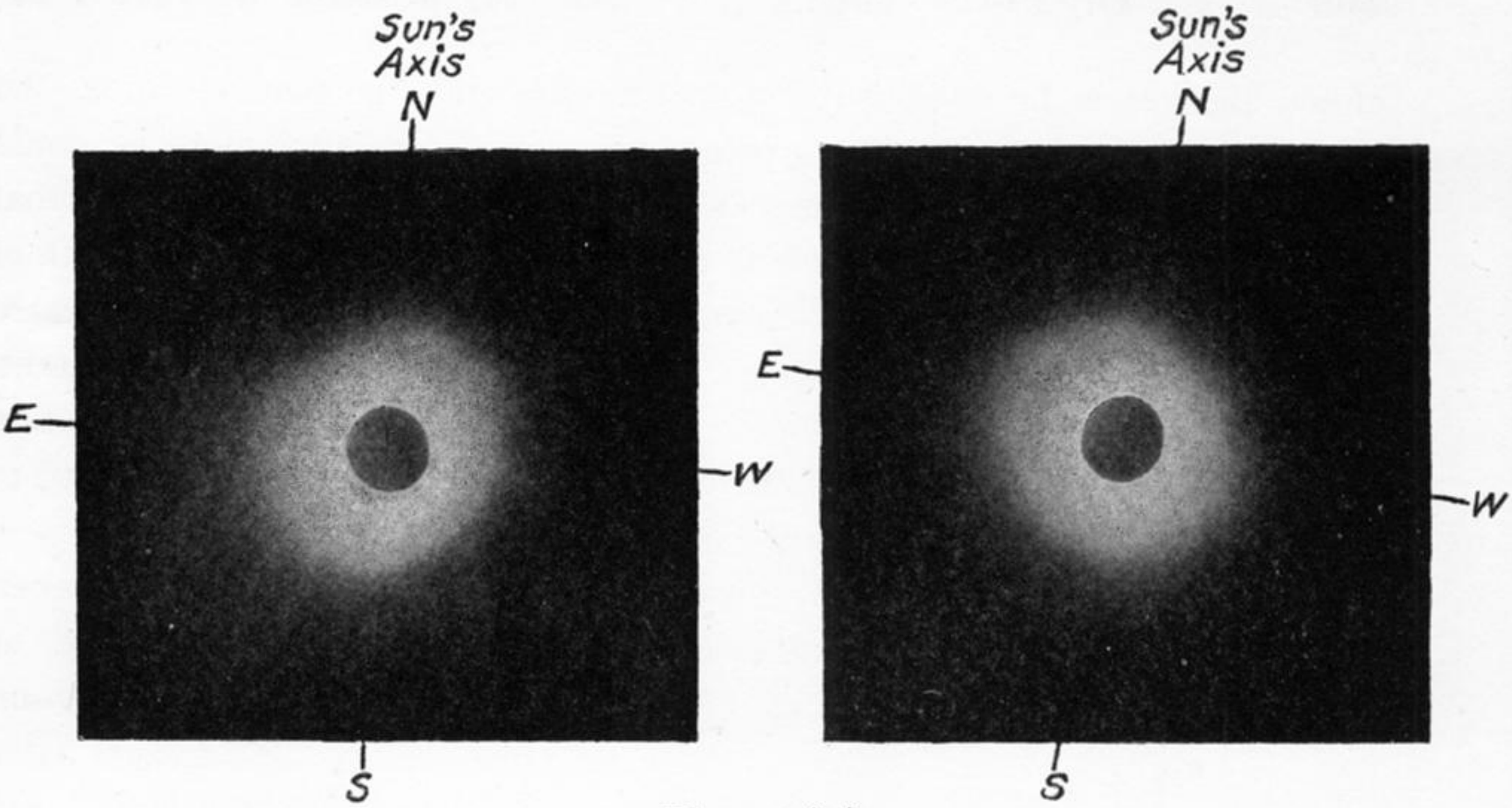
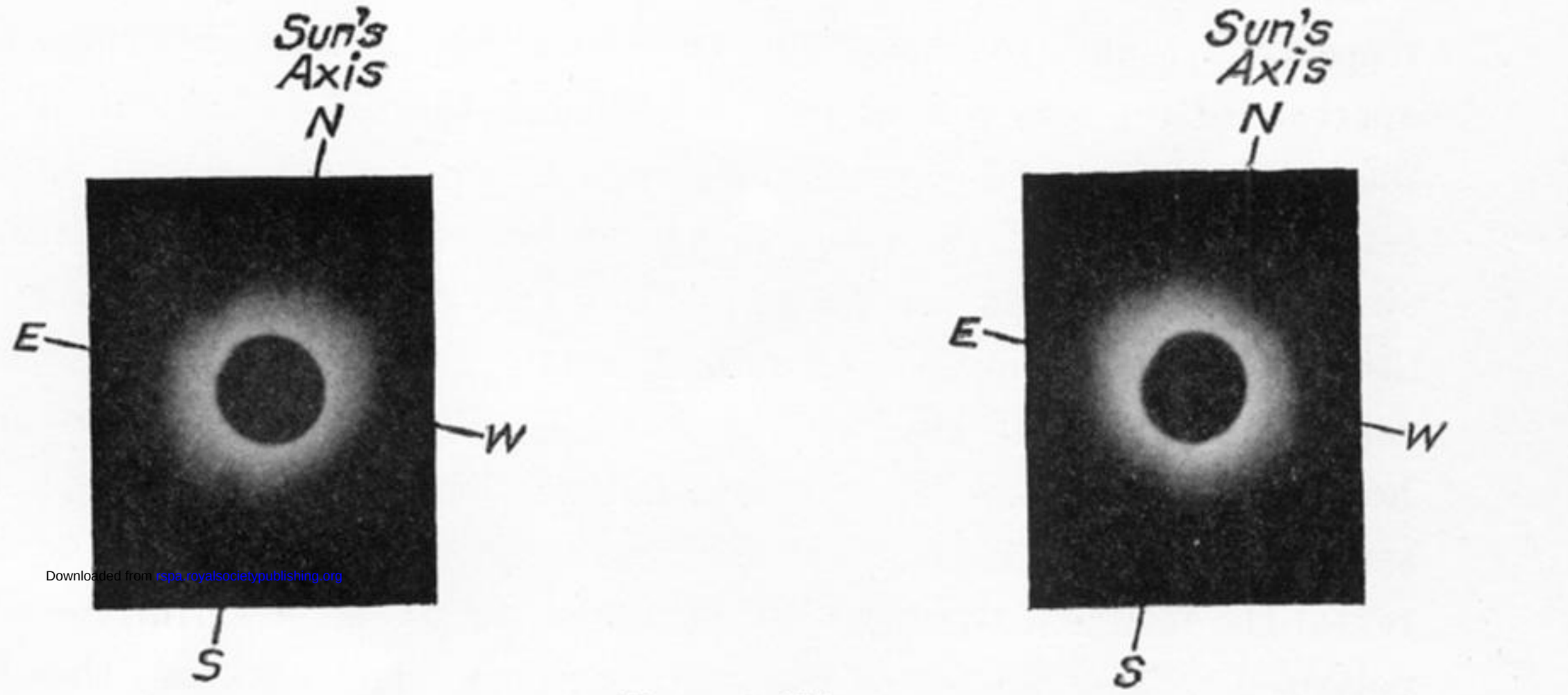


FIG. 3 (a).



Downloaded from rspa.royalsocietypublishing.org

FIG. 3 (b).

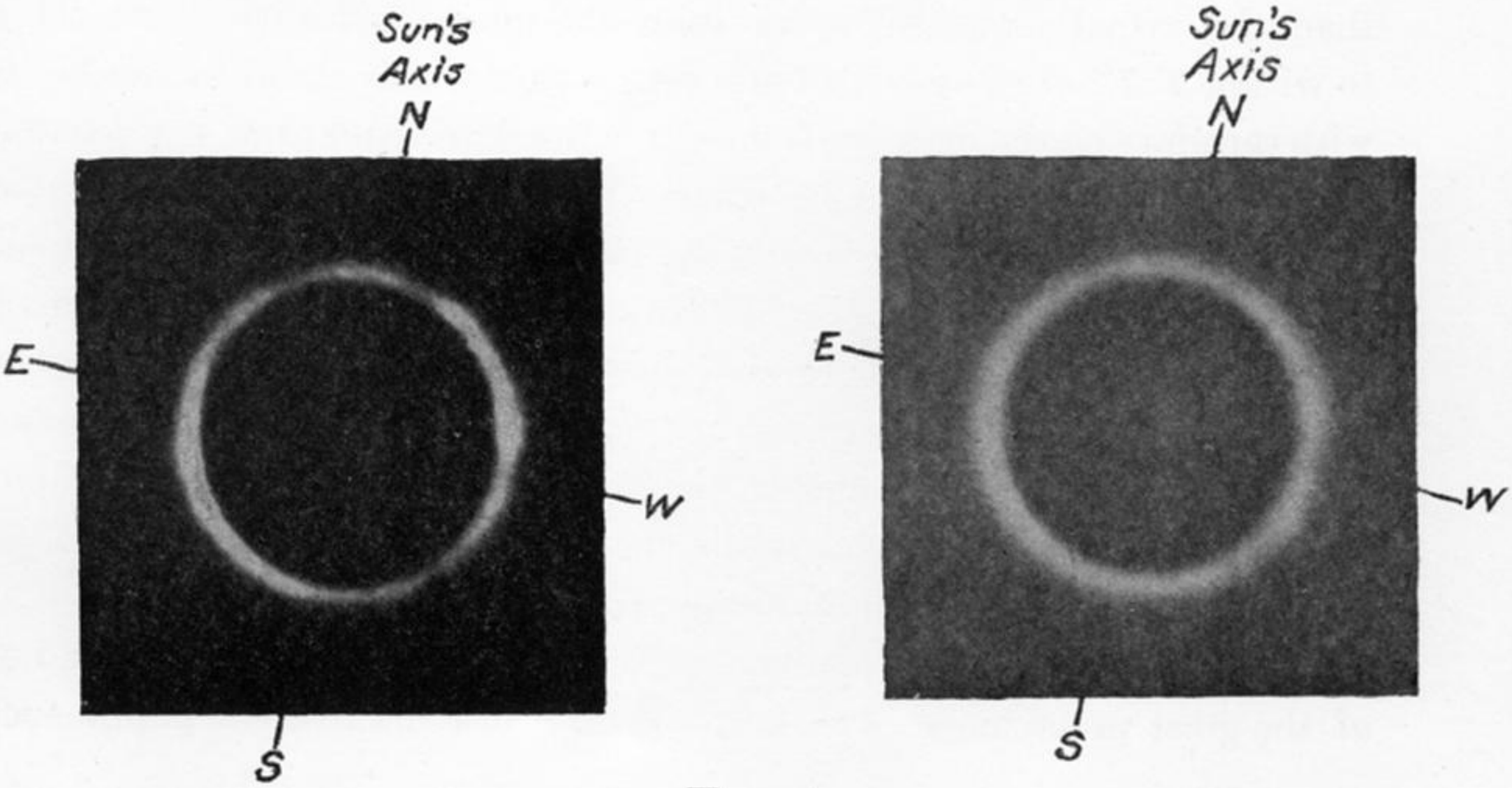
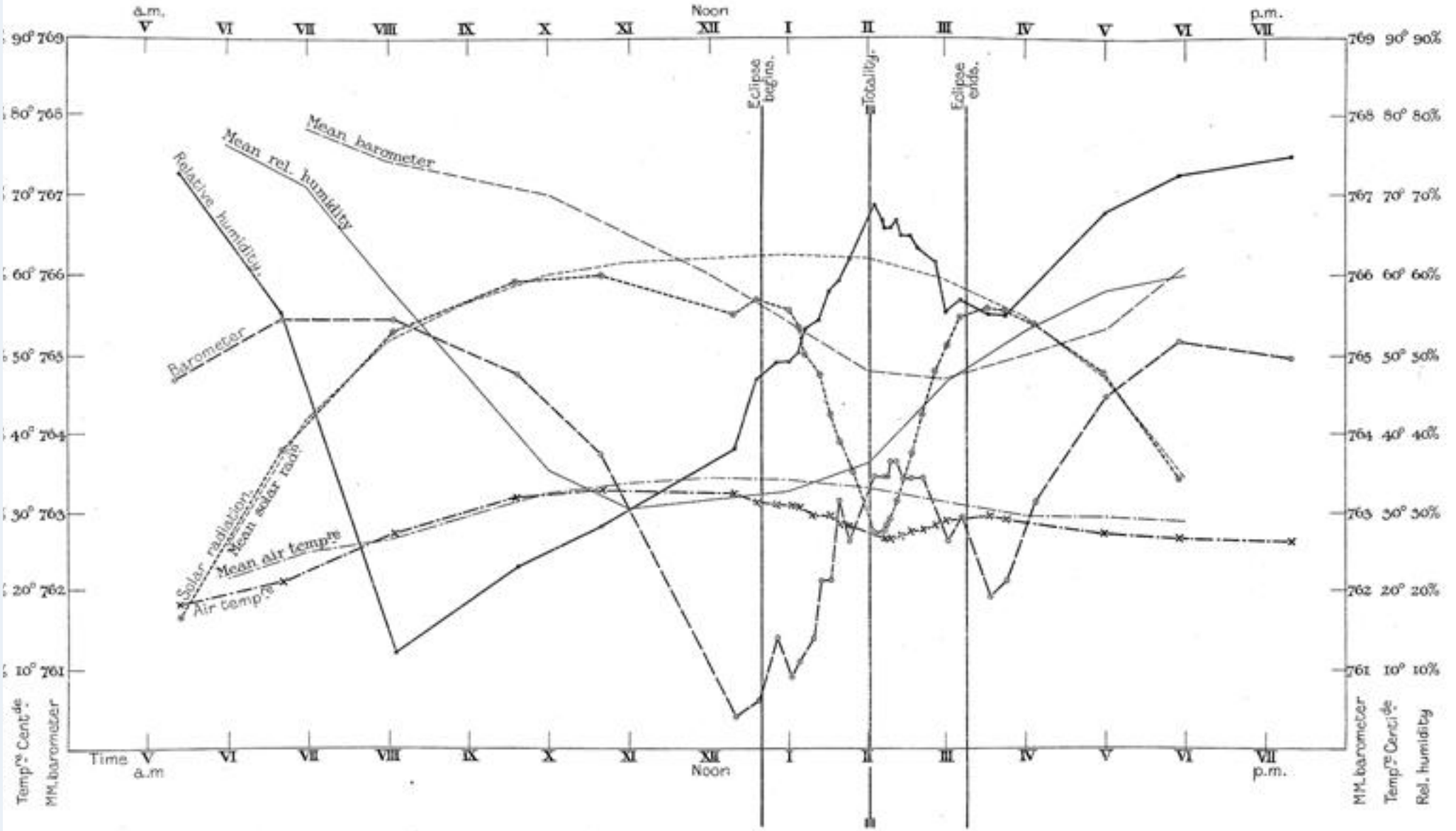
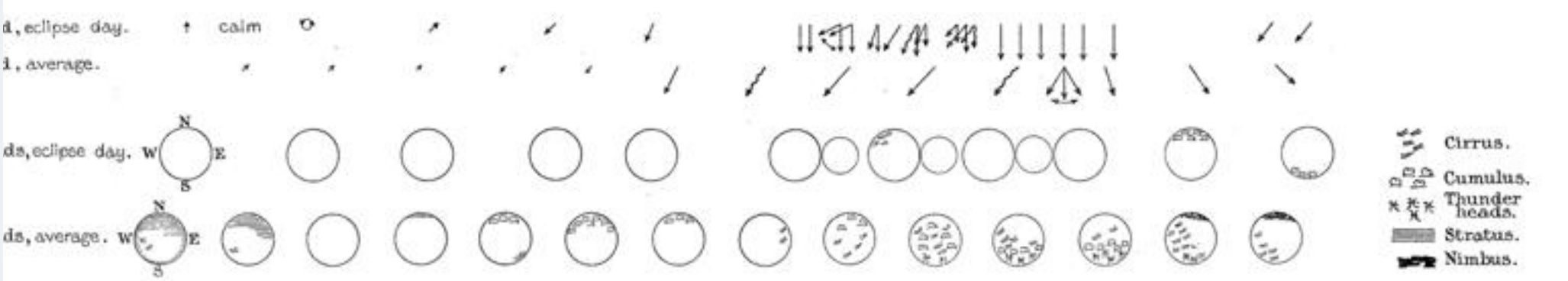


FIG. 4.

PROCEEDINGS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES


a.m.
Noon
p.m.
V VI VII VIII IX X XI XII I II III IV V VI VII
Eclipse begins.
Totality.
Eclipse ends.
Mean barometer
Mean rel. humidity
Relative humidity.
Barometer
Solar radiation.
Mean solar radn.
Mean air temp^re
Air temp^re
90° 769
80° 768
70° 767
60° 766
50° 765
40° 764
30° 763
20° 762
10° 761
769 90° 90%
768 80° 80%
767 70° 70%
766 60° 60%
765 50° 50%
764 40° 40%
763 30° 30%
762 20° 20%
761 10° 10%
Temp^re Centigde.
MM. barometer
Time
Rel. humidity


d, eclipse day.
calm
d, average.
ds, eclipse day.
ds, average.
N
W
E
S
Cirrus.
Cumulus.
Thunder heads.
Stratus.
Nimbus.